US007358907B2

(12) **United States Patent**
**Takaba et al.**

(10) **Patent No.: US 7,358,907 B2**
(45) **Date of Patent: Apr. 15, 2008**

(54) **SMALL-SIZED ANTENNA**

(75) Inventors: **Shinichi Takaba**, Hitachi (JP); **Makoto Usui**, Hitachi (JP)

(73) Assignee: **Hitachi Cable, Ltd.**, Tokyo (JP)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 314 days.

(21) Appl. No.: **11/077,158**

(22) Filed: **Mar. 11, 2005**

(65) **Prior Publication Data**

US 2006/0097928 A1 May 11, 2006

(30) **Foreign Application Priority Data**

Nov. 5, 2004 (JP) ..... 2004-321925

(51) **Int. Cl.**
***H01Q 1/24*** (2006.01)

(52) **U.S. Cl.** ..... **343/702**

(58) **Field of Classification Search** ..... 343/702, 343/700 MS, 829, 841, 846
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 5,856,912 | A * | 1/1999 | Miller et al. | 361/737 |
| 6,040,803 | A * | 3/2000 | Spall | 343/700 MS |
| 6,110,576 | A * | 8/2000 | Decker et al. | 428/300.1 |
| 6,333,716 | B1 * | 12/2001 | Pontoppidan | 343/702 |
| 2004/0029329 | A1 * | 2/2004 | Borghs et al. | 438/167 |

FOREIGN PATENT DOCUMENTS

| | | |
|---|---|---|
| JP | 7-288422 | 10/1995 |
| JP | 2002-299934 | 10/2002 |

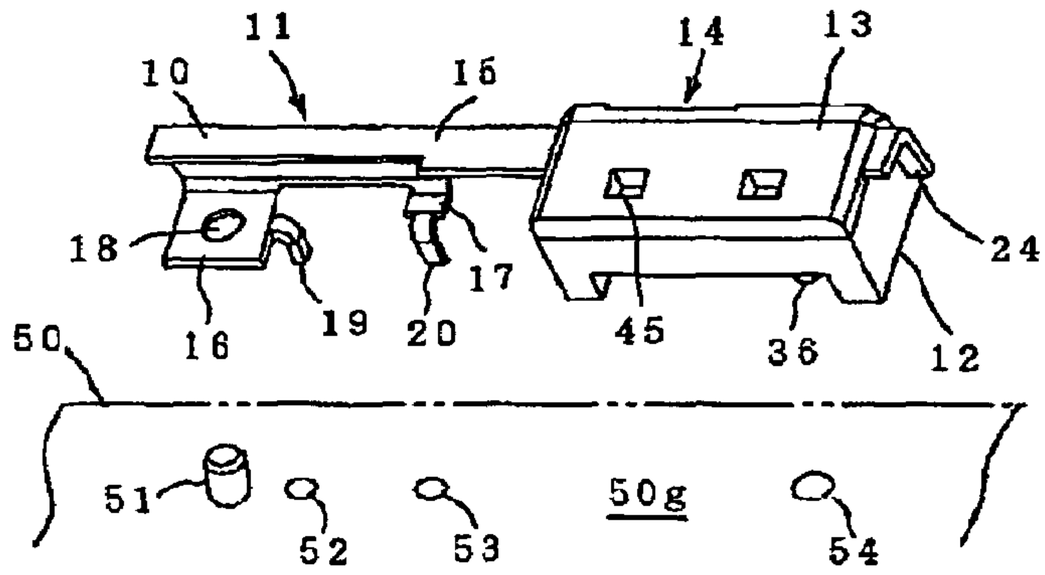
* cited by examiner

*Primary Examiner*—Huedung Mancuso
(74) *Attorney, Agent, or Firm*—McGinn IP Law Group, PLLC

(57) **ABSTRACT**

A small-sized antenna is adapted to be mounted on a circuit substrate. The antenna has an antenna body and a resin-molded body that has a first resin-molded body and a second resin-molded body. The antenna body is sandwiched by the first and second resin-molded bodies. The first resin-molded body engages to the second resin-molded body, and the first resin-molded body is mounted on the circuit substrate.

**14 Claims, 5 Drawing Sheets**




11:ANTENNA BODY

12:FIRST RESIN-MOLDED BODY

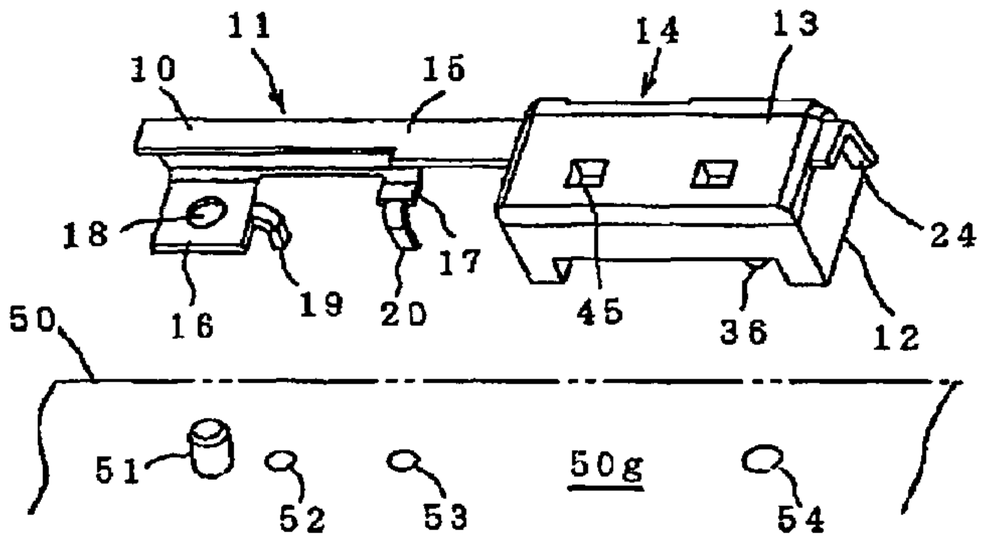
13:SECOND RESIN-MOLDED BODY

50:CIRCUIT SUBSTRATE

50g:GROUND PLANE

54:POSITIONING HOLE

FIG. 1




11:ANTENNA BODY

12:FIRST RESIN-MOLDED BODY

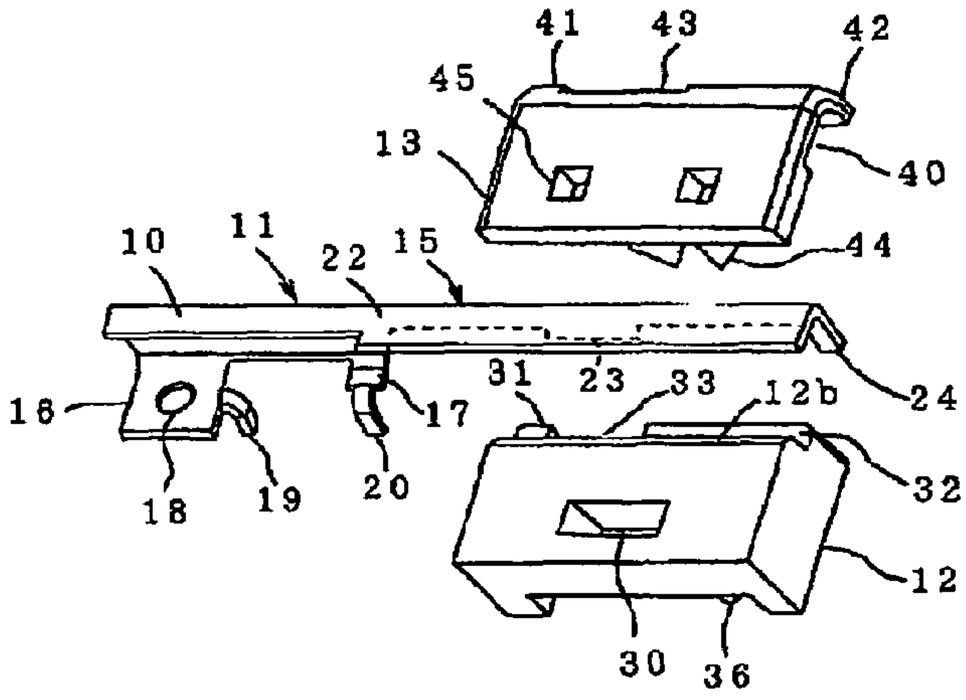
13:SECOND RESIN-MOLDED BODY

50:CIRCUIT SUBSTRATE

50g:GROUND PLANE

54:POSITIONING HOLE

FIG. 2




15:INVERTED-F ANTENNA ELEMENT

16:GROUND PIECE

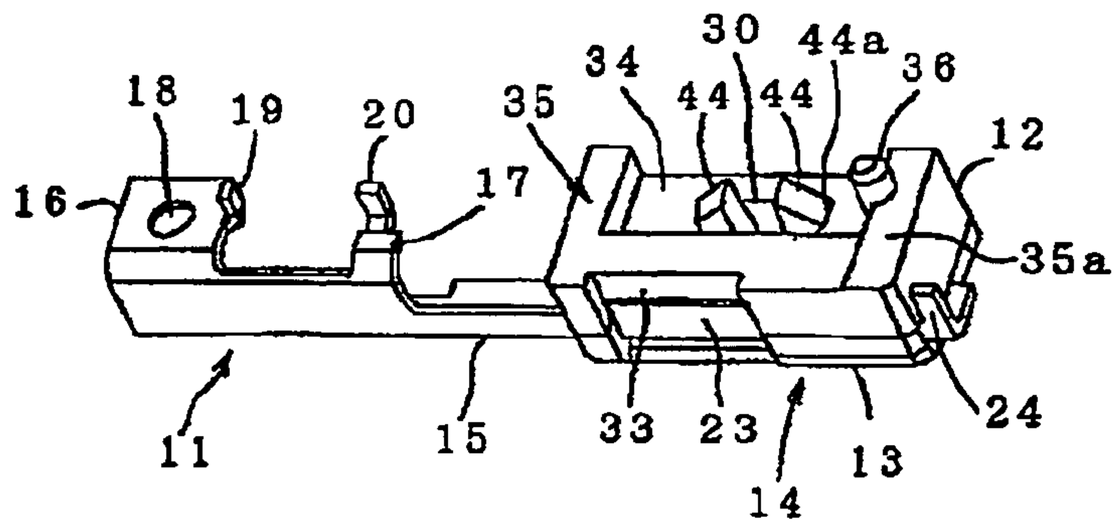
17:POWER FEED PIECE

20:POWER FEED TERMINAL

30:ENGAGING HOLE

44:ENGAGING PIECE

FIG.3




12:FIRST RESIN-MOLDED BODY

23:ENGAGING PIECE

24:STOPPER PIECE

33:ENGAGING GROOVE

34:RECESSED GROOVE

35:MOUNTING SURFACE

36:BOSS

FIG.5A

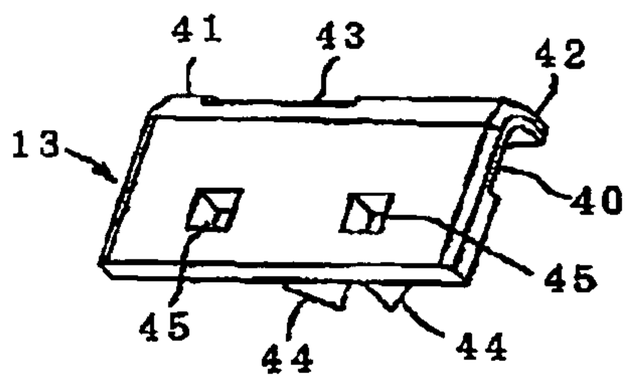
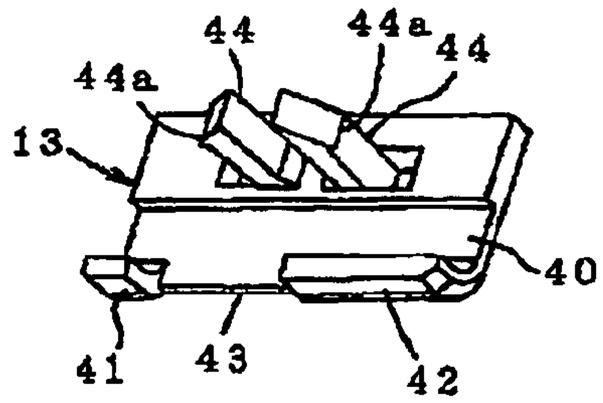



FIG.5B




13:SECOND RESIN-MOLDED BODY

40:HOUSING GROOVE

41,42:COVERING PIECE

43:NOTCHED PORTION

44:ENGAGING PIECE

45:HOLE

FIG.4A

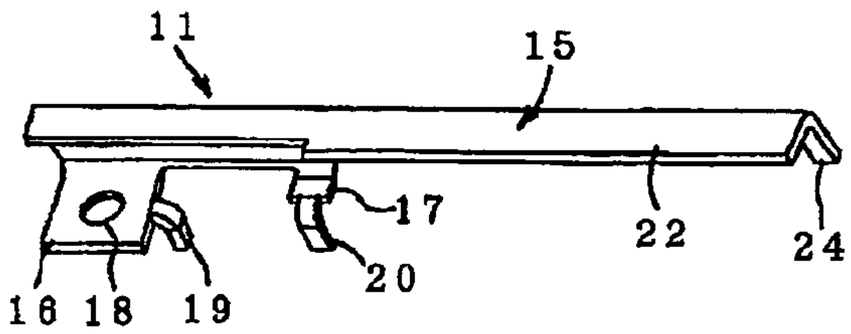



FIG.4B

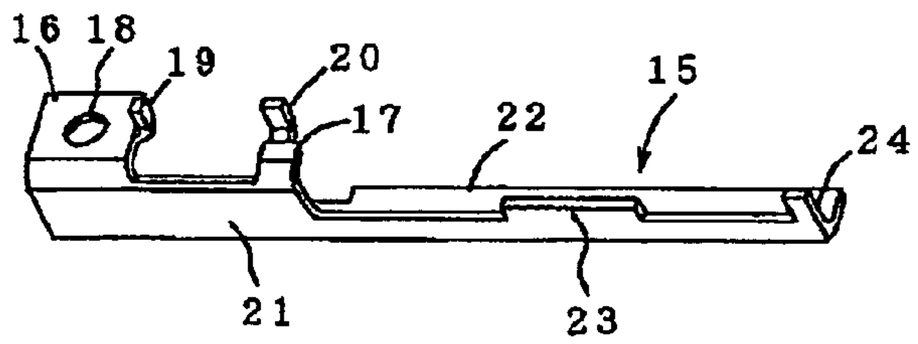



FIG.4C

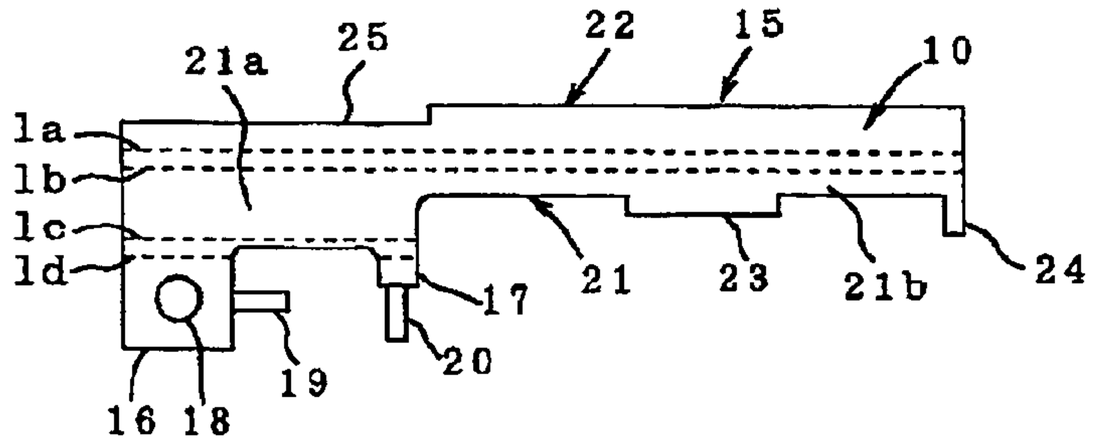
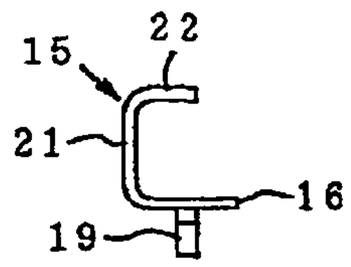



FIG.4D




11:ANTENNA BODY

15:INVERTED-F ANTENNA ELEMENT

16:GROUND PIECE

17:POWER FEED PIECE

18:HOLE

19:GROUND TERMINAL

20:POWER FEED TERMINAL

21:UPRIGHT ANTENNA PIECE

22:HORIZONTAL ANTENNA PIECE

23:ENGAGING PIECE

24:STOPPER PIECE

1a-1d:FOLD LINE

21b:UPRIGHT ELEMENT PORTION

16:GROUND PIECE

21:UPRIGHT ANTENNA PIECE

22:HORIZONTAL ANTENNA PIECE

FIG.6A

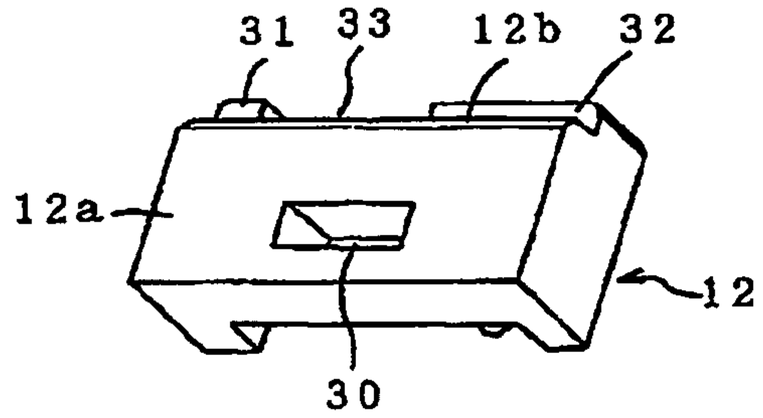
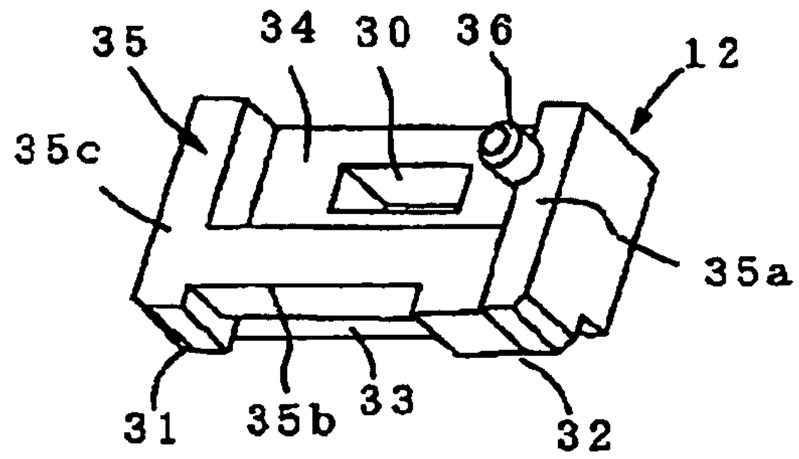



FIG.6B




12:FIRST RESIN-MOLDED BODY

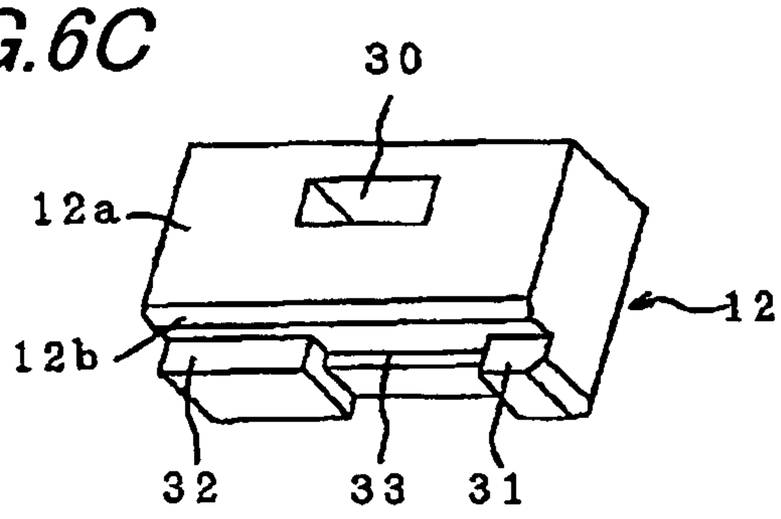
30:ENGAGING HOLE

34:RECESSED GROOVE

35:MOUNTING SURFACE

35a:TIP SIDE PORTION

FIG.6C




31,32:STAGE PORTION

FIG. 7A

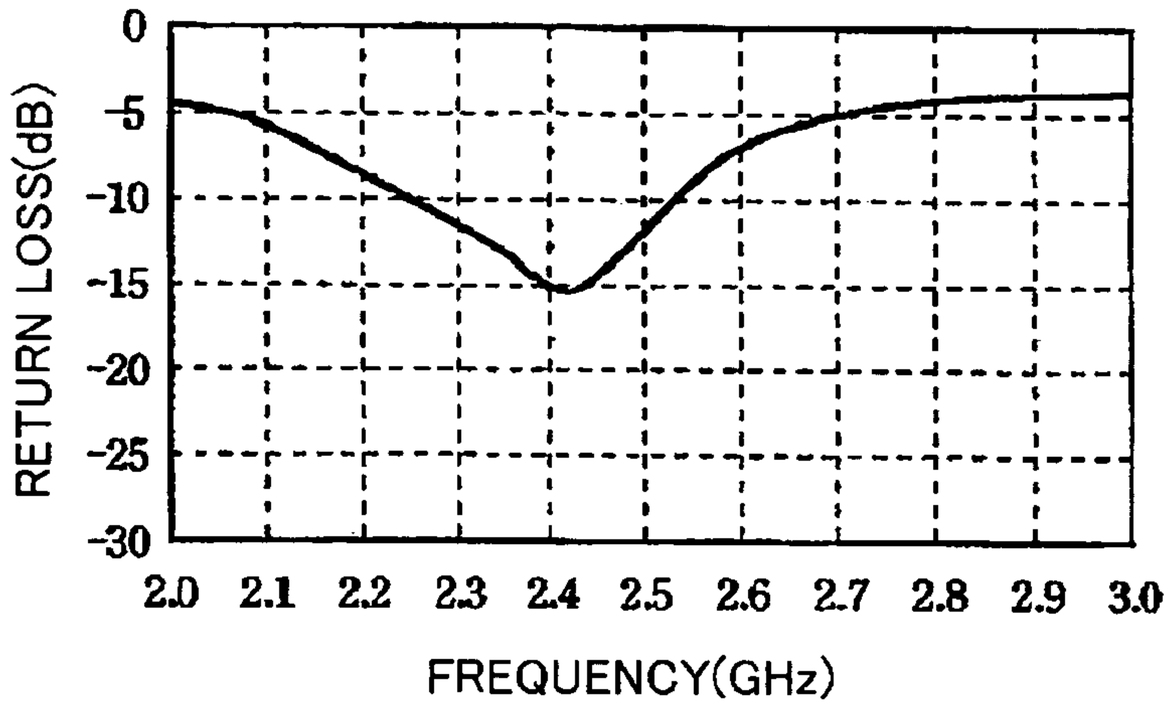



FIG. 7B

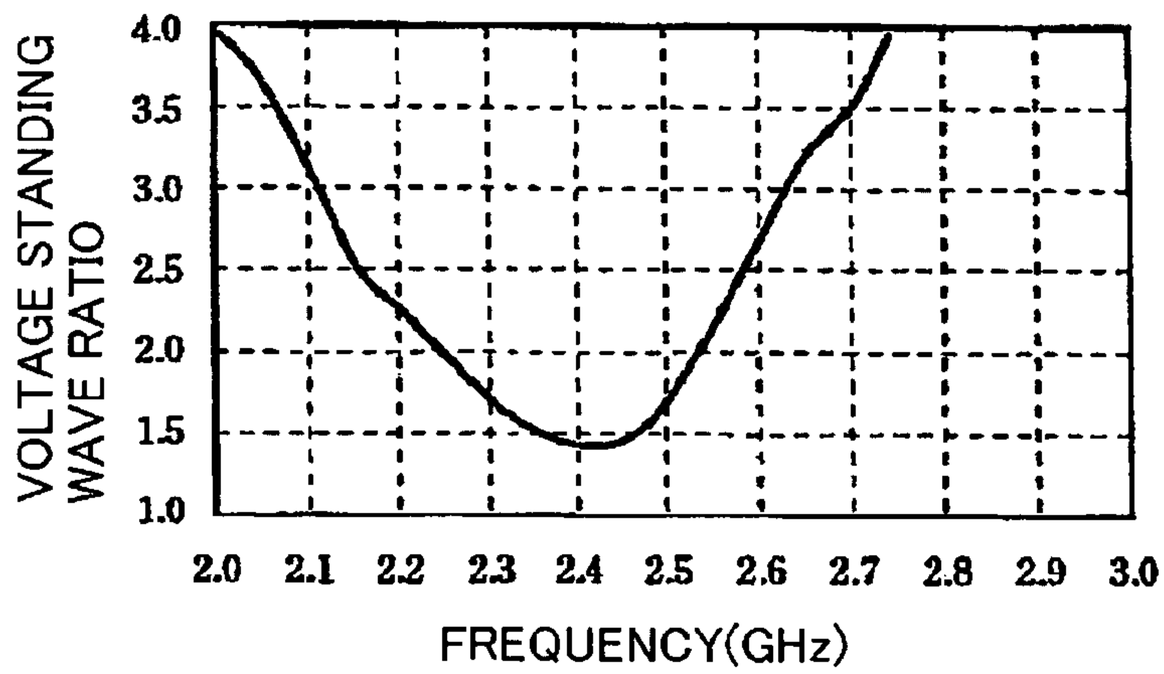
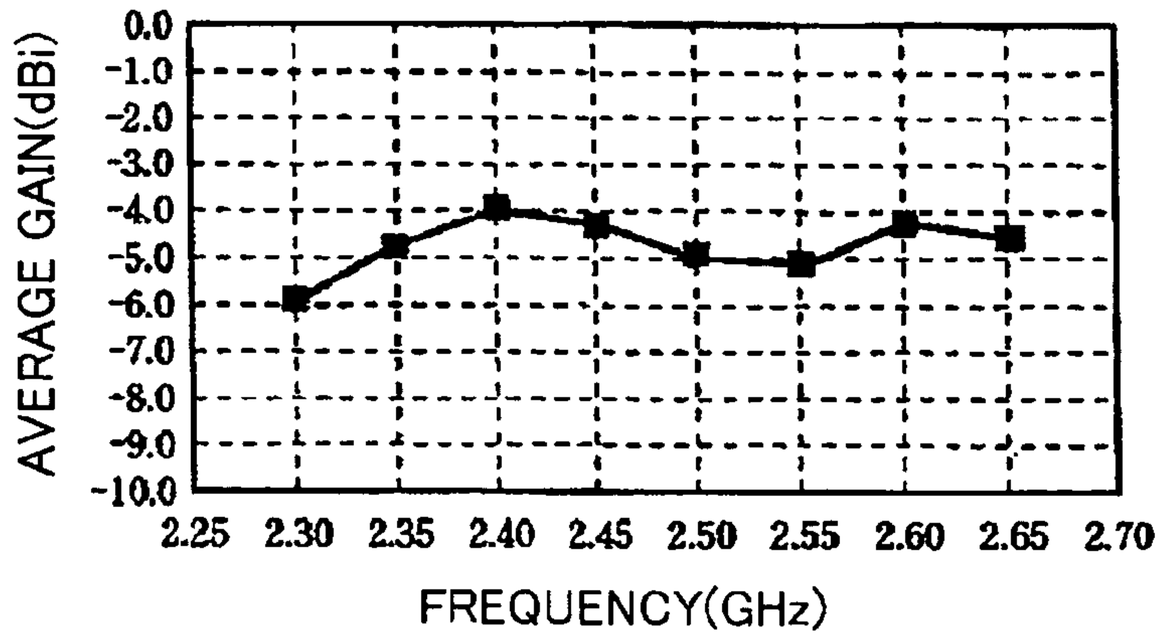



FIG. 7C



# SMALL-SIZED ANTENNA

The present application is based on Japanese patent application No. 2004-321925, the entire contents of which are incorporated herein by reference.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a small-sized antenna which is integrated into mobile devices, and the like.

2. Description of the Related Art

As next-generation wireless data communication technology, Bluetooth which uses a band of 2.4 GHz that can be used without a license has been in the limelight, and is integrated into mobile devices such as mobile phones, notebook PCs, PDAs (Personal Digital Assistances), etc., and is expected to become increasingly common.

Circuit components such as antennas, wireless modules, etc., used in the Bluetooth are required to be reduced in size and weight, and it is important to be small in the area occupied by an antenna to be mounted on a circuit.

Although, as a small-sized antenna for this Bluetooth, an inverted-F monopole antenna, or the like has been developed, it is very small (for example, 20 mm×3 mm×3 mm), so that, to mount it on a circuit substrate, a metal conductor which serves as an antenna has to be mounted by integrating it with a resin-molded body (e.g. see Japanese patent application laid-open Nos. 2002-299934 and 7-288422).

However, since, as mentioned above, the small-sized antenna for Bluetooth is very small (about 20 mm×3 mm×3 mm), and is resin-molded together with the metal conductor, sealing of the metal conductor and mold, and the like is required, and there is therefore the problem that the mold tends to be costly.

In particular, as small-sized antennas of this kind tend to be often improved in their shape, changing the mold accordingly would be more costly.

## SUMMARY OF THE INVENTION

It is an object of the present invention to provide a structure of small-sized antenna that the manufacturing cost can be reduced.

(1) According to one aspect of the invention, a small-sized antenna for being mounted on a circuit substrate comprises:

an antenna body; and

a resin-molded body that comprises a first resin-molded body and a second resin-molded body,

wherein the antenna body is sandwiched by the first and second resin-molded bodies,

the first resin-molded body engages to the second resin-molded body, and

the first resin-molded body is adapted to be mounted on the circuit substrate.

(2) According to another aspect of the invention, a small-sized antenna for being mounted on a circuit substrate comprises:

an antenna body; and

a resin-molded body that comprises a first resin-molded body and a second resin-molded body,

wherein the antenna body is sandwiched by the first and second resin-molded bodies,

the first resin-molded body engages to the second resin-molded body,



the first resin-molded body is adapted to be mounted on the circuit substrate,

the antenna body comprises a ground piece to be seated on the circuit substrate, and an inverted-F antenna element that rises upright from the ground piece and extends parallel to the circuit substrate, the inverted-F antenna element comprising a power feed piece.

It is preferred that the first and second resin-molded bodies sandwich part of the inverted-F antenna element situated nearer its tip side in relation to the power feed piece.

(3) According to another aspect of the invention, a small-sized antenna for being mounted on a circuit substrate comprises:

an antenna body; and

a resin-molded body that comprises a first resin-molded body and a second resin-molded body,

wherein the antenna body is sandwiched by the first and second resin-molded bodies,

the first resin-molded body engages to the second resin-molded body,

the first resin-molded body is adapted to be mounted on the circuit substrate,

the antenna body comprises an inverted-F antenna element that is formed in a cross-sectional L shape, the inverted-F antenna element comprising an engaging piece,

the first resin-molded body is formed substantially in a rectangular parallelepiped shape, the first resin-molded body comprising a top edge portion to contact the inverted-F antenna element and an engaging groove to engage to the engaging piece of the inverted-F antenna element, and

the second resin-molded body is formed substantially in a plate shape to cover the first resin-molded body while sandwiching the inverted-F antenna element therebetween, the second resin-molded body comprising an engaging piece to engage to an engaging hole of the first resin-molded body.

It is preferred that the first resin-molded body comprises on its back side a protruded boss to be fitted into a positioning hole of the circuit substrate.

It is preferred that the ground piece comprises a hole for attaching the small-sized antenna to the circuit substrate.

It is preferred that the ground piece comprises a ground terminal folded downward, the power feed piece comprises a power feed terminal folded downward, and the ground terminal and the power feed terminal are adapted to be connected through a through-hole provided in the circuit substrate to a power supply circuit.

<Advantages of the Invention>

In the invention, the first and second resin-molded bodies engage to each other while sandwiching the antenna body therebetween and, in which state, the antenna body is mounted on the circuit substrate. Thus, the first and second resin-molded bodies can be each made by molding etc. without incorporating the antenna body. For this reason, the manufacturing cost can be reduced.

## BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiments according to the invention will be explained below referring to the drawings, wherein:

FIG. **1** illustrates one embodiment of a small-sized antenna according to the present invention, illustrating a perspective view of a state where the small-sized antenna is to be mounted onto a circuit substrate;

FIG. **2** illustrates a perspective view of a state of assembling a metal conductor and a resin-molded body in the small-sized antenna of FIG. **1**;

FIG. **3** illustrates a perspective view where the small-sized antenna illustrated in FIG. **1** is reversed;

FIGS. **4**A-**4**D illustrate perspective and development views of the metal conductor in the small-sized antenna illustrated in FIG.**1**;

FIGS. **5**A-**5**B illustrate a perspective view of a second resin-molded body in the small-sized antenna illustrated in FIG.**1**;

FIGS. **6**A-**6**C illustrate a perspective view of a first resin-molded body in the small-sized antenna illustrated in FIG.**1**; and

FIGS. **7**A-**7**C show antenna characteristics of a small-sized antenna of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. **1-6** illustrate one embodiment of a small-sized antenna according to the present invention. FIG. **1** illustrates a perspective view of a state where the small-sized antenna is to be mounted onto a circuit substrate. FIG. **2** illustrates a perspective view of a state of assembling a metal conductor and a resin-molded body in the small-sized antenna. FIG. **3** illustrates a perspective view where the small-sized antenna illustrated in FIG. **1** is reversed. FIG. **4** illustrates perspective and development views of the metal conductor in the small-sized antenna. FIG. **5** illustrates a perspective view of a second resin-molded body in the small-sized antenna. FIG. **6** illustrates a perspective view of a first resin-molded body in the small-sized antenna.

As in illustrated in FIG. **1-3**, the small-sized antenna of the invention comprises an antenna body **11** formed of a metal conductor **10**, and a resin-molded body **14** consisting of first and second resin-molded bodies **12** and **13** for sandwiching that antenna body **11** therebetween for mounting the antenna body **11** on a circuit substrate **50**.

This antenna body **11**, and the first and second resin-molded bodies **12** and **13** constituting the resin-molded body **14** is explained below.

FIG. **4**(*a*) illustrates a perspective view of the antenna body **11**; FIG. **4**(*b*) illustrates a perspective view of a state where the antenna body **11** illustrated in FIG. **4**(*a*) is reversed; FIG. **4**(*c*) illustrates a development view of the metal conductor **10** before the antenna body **11** is formed; and FIG. **4** (*d*) illustrates the left side view of FIG. **4**(*a*).

As illustrated in FIG. **4** (*c*), the antenna body **11** is formed of the metal conductor **10** formed by die-cutting of a metal plate (0.3 mm thick) of e.g., phosphor bronze with a press, followed by folding thereof, as illustrated.

The metal conductor **10** has an inverted-F antenna element **15** formed by being folded in an L shape along fold lines **1***a* and **1***b*, a ground piece **16** formed by being folded along fold lines **1***c* and **1***d* in an end portion of that inverted-F antenna element **15**, and a power feed piece **17** formed by being likewise folded along fold lines **1***c* and **1***d* on the tip side of the inverted-F antenna element **15** relative to the ground piece **16**.

The ground piece **16** has a hole **18** formed for engaging a boss **51** of the circuit substrate **50** (see FIG. **1**) or for a screw being fastened to the circuit substrate **50**, and a ground terminal **19** formed by being folded for being inserted and soldered into a through hole **52** of the circuit substrate **50** (see FIG. **1**).

The power feed piece **17** has a power feed terminal **20** formed by being folded for being inserted and soldered into a through hole **53** of the circuit substrate **50** (see FIG. **1**).

The inverted-F antenna element **15** comprises an upright antenna piece **21** caused to rise upright by being folded along fold lines **1***c* and **1***d* from the ground piece **16** and the power feed piece **17**, and a horizontal antenna piece **22** folded horizontally above the ground piece **16** and the power feed piece **17** along fold lines **1***a* and **1***b* from that upright antenna piece **21**.

The upright antenna piece **21** comprises a base portion **21***a* positioned in the ground piece **16** and the power feed piece **17**, and an upright element portion **21***b* extending directly from the base portion **21***a* so as to be formed in a more elongated shape than the base portion **21***a* and caused to float up from a ground plane **50***g* of the circuit substrate **50** (see FIG. **1**). This upright element portion **21***b* is provided with an engaging piece **23** and a stopper piece **24** which engage the resin-molded body **14**.

The horizontal antenna piece **22** has a notched portion **25** positioned on the side of the ground piece **16** and the power feed piece **17**.

The antenna body **11** is formed in such a way that, for example, the length of the inverted-F antenna element **15** is 21.6 mm; the width of the tip of the inverted-F antenna element **15** is 1.85 mm; and the height from the ground piece **16** to the horizontal antenna piece **22** is 3 mm.

Referring to FIGS. **5** and **6** next, the first and second resin-molded bodies **12** and **13** constituting the resin-molded body **14** is explained.

FIG. **5**(*a*) illustrates a perspective view of the second resin-molded body **13**; and FIG. **5**(*b*) illustrates a perspective view where the second resin-molded body **13** illustrated in FIG. **5**(*a*) is reversed. FIG. **6**(*a*) illustrates a perspective view of the first resin-molded body **12**; FIG. **6**(*b*) illustrates a perspective view where the first resin-molded body **12** illustrated in FIG. **6**(*a*) is reversed; and FIG. **6**(*c*) illustrates a perspective view where the first resin-molded body **12** illustrated in FIG. **6**(*a*) is viewed from the back side.

As illustrated in FIG. **6**(*a*), the first resin-molded body **12** is formed in a substantially rectangular parallelepiped shape (e.g., 9 mm long, 4.5 mm wide, 2.7 mm high), and has a rectangular engaging hole **30** formed in a top face **12***a*; a top edge portion **12***b* formed so as to come into contact with the internal surface side of the L-shaped inverted-F antenna element **15** of the antenna body **11**; stage portions **31** and **32** formed on a top side face so as to come into contact with the upright element portion **21***b* of the inverted-F antenna element **15**; and an engaging groove **33** formed between the stage portions **31** and **32** so as to engage the engaging piece **23** of the inverted-F antenna element **15**.

As illustrated in FIG. **6**(*b*), the first resin-molded body **12** has a recessed groove **34** formed in its back face, and a U-shaped mounting surface **35** which is mounted on the circuit substrate **50** (see FIG. **1**) is formed around the recessed groove **34**. A tip side portion **35***a* of this mounting surface **35** which is on the tip side of the inverted-F antenna element **15** is made slightly higher (the order of 0.1 mm) than other front side portion **35***b* and back end side portion **35***c*, thereby allowing the ground piece **16** and the power feed piece **17** of the antenna body **11** to be securely mounted on the circuit substrate **50**.

A boss **36** which is positioned in the tip side portion **35***a* of the mounting surface **35** and the recessed groove **34** to be fitted into a positioning hole **54** of the circuit substrate **50** is formed so as to protrude from the mounting surface **35**.

As illustrated in FIGS. **5**(*a*)and **5**(*b*), the second resin-molded body **13** is formed in a plate shape (e.g., 0.8 mm thick), and has a housing groove **40** formed in its back face so as to come into contact with the external surface side of

the L-shaped inverted-F antenna element **15** of the antenna body **11**; covering pieces **41** and **42** formed on the front edge side so as to come into contact with the stage portions **31** and **32** of the first resin-molded body **12** with the inverted-F antenna element **15** sandwiched therebetween; and a notched portion **43** formed between the covering pieces **41** and **42** so as to cause the engaging piece **23** of the inverted-F antenna element **15** to open.

A pair of engaging pieces **44**, **44** which engages the engaging hole **30** of the first resin-molded body **12** is formed in the back face of the second resin-molded body **13** which comes into contact with the top face **12***a* of the first resin-molded body **12**. The engaging pieces **44**, **44** has a hook portion **44***a* formed so as to engage a surface of the recessed groove **34** of the first resin-molded body **12** after being inserted into the engaging hole **30**. The second resin-molded body **13** has holes **45**, **45** cut in positions of both sides of the engaging pieces **44**, **44**, which are for handling for sandwiching the antenna body **11** between the first and second resin-molded body **12** and **13** for fitting the antenna body **11** therebetween.

FIGS. **1-3** illustrate states where the antenna body **11** and the resin-molded body **14** consisting of first and second resin-molded bodies **12** and **13** are assembled.

As illustrated in FIG. **2**, the inverted-F antenna element **15** of the antenna body **11** is brought into contact with the top edge portion **12***b* of the first resin-molded body **12**; as illustrated in FIG. **3**, the engaging piece **23** is caused to engage the engaging groove **33** of the first resin-molded body **12**, while the stopper piece **24** is brought into contact with a side face of the stage portion **32** of the first resin-molded body **12**; and in that state, the second resin-molded body **13** is fitted over the first resin-molded body **12** and the engaging piece **44** is fitted into the engaging hole **30** of the first resin-molded body **12**, thereby causing the hook portion **44***a* of the engaging piece **44** to engage the surface of the recessed groove **34** so as to combine the second resin-molded body **13** with the first resin-molded body **12** with the antenna body **11** sandwiched therebetween, allowing the antenna body **11** to be held by the resin-molded body **14**.

When this small-sized antenna is mounted on the circuit substrate **50**, the boss **36** of the resin-molded body **14** is inserted into the positioning hole **54** of the circuit substrate **50**, and the hole **18** of the ground piece **16** of the antenna body **11** is fitted onto the boss **51** of the circuit substrate **50**, thereby allowing the small-sized antenna to be mounted on the circuit substrate **50**. In this case, since the tip side portion **35***a* of the mounting surface **35** of the first resin-molded body **12** which is on the tip side of the antenna body **11** is made slightly higher, the ground piece **16** and the power feed piece **17** of the antenna body **11** can be securely brought into contact with the circuit substrate **50**.

Also, the ground terminal **19** of the ground piece **16** and the power feed terminal **20** of the power feed piece **17** are inserted into the through holes **52** and **53** of the circuit substrate **50** for being soldered from the back side of the circuit substrate **50** for being connected to a power supply circuit (not illustrated).

In this manner, in the invention, when the antenna body **11** is held by the resin-molded body **14**, the resin-molded body **14** is formed by the first and second resin-molded bodies **12** and **13**, and the antenna body **11** is sandwiched between the first and second resin-molded bodies **12** and **13** for holding it by the engagement of both. This allows obviating the conventional need to integrally mold the antenna and the resin, but only using a mold for molding the first and second resin-molded bodies **12** and **13**, so that the cost of the mold can thereby be substantially reduced, while freely responding even to modifications of antenna design.

FIG. **7** shows characteristics of a small-sized antenna of the present invention. FIG. **7**(*a*) shows the relationship between the frequency and the return loss; FIG. **7**(*b*) shows the relationship between the frequency and the voltage standing wave ratio; and FIG. **7**(*c*) shows average gain characteristics. Good antenna characteristics have been obtained for a 2.4 GHz band: the return loss is −15 dB; the voltage standing wave ratio is 1.5; and the average gain is −4.0 dBi.

Although the invention has been described with respect to the specific embodiments for complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art which fairly fall within the basic teaching herein set forth.

What is claimed is:

**1**. A small-sized antenna for being mounted on a circuit substrate, comprising:

an antenna body; and

a resin-molded body that comprises a first resin-molded body and a second resin-molded body,

wherein the antenna body is held in place by an engagement of the first and second resin-molded bodies,

the first resin-molded body engages to the second resin-molded body, and

the first resin-molded body is adapted to be mounted on the circuit substrate.

**2**. The small-sized antenna according to claim **1**, wherein:

the first resin-molded body comprises on its back side a protruded boss to be fitted into a positioning hole of the circuit substrate.

**3**. The small-sized antenna according to claim **1**, wherein:

the first and second resin-molded bodies sandwich only a part of the antenna body.

**4**. The small-sized antenna according to claim **1**, wherein:

at least one of the first and second resin-molded bodies comprises a groove to bold the antenna body.

**5**. The small-sized antenna according to claim **1**, wherein:

the antenna body comprises a folded metal plate.

**6**. A small-sized antenna for being mounted on a circuit substrate, comprising:

an antenna body; and

a resin-molded body that comprises a first resin-molded body and a second resin-molded body,

wherein the antenna body is held in place by an engagement of the first and second resin-molded bodies,

the first resin-molded body engages to the second resin-molded body,

the first resin-molded body is adapted to be mounted on the circuit substrate,

the antenna body comprises a round piece to be seated on the circuit substrate, and an inverted-F antenna element that rises upright from the pound piece and extends parallel to the circuit substrate, the inverted-F antenna element comprising a power feed piece.

**7**. The small-sized antenna according to claim **6**, wherein:

the first and second resin-molded bodies sandwich part of the inverted-F antenna element situated nearer its tip side in relation to the power feed piece.

**8**. The small-sized antenna according to claim **6**, wherein:

the first resin-molded body comprises on its back side a protruded boss to be fitted into a positioning hole of the circuit substrate.

9. The small-sized antenna according to claim 6, wherein:

the ground piece comprises a hole for attaching the small-sized antenna to the circuit substrate.

10. The small-sized antenna according to claim 6, wherein:

the ground piece comprises a ground terminal folded downward,

the power feed piece comprises a power feed terminal folded downward, and

the ground terminal and the power feed terminal are adapted to be connected through a through-hole provided in the circuit substrate to a power supply circuit.

11. The small-sized antenna according to claim 6, wherein:

at least one of said first and second resin-molded bodies comprises a groove to hold the antenna body.

12. The small-sized antenna according to claim 6, wherein:

the antenna body comprises a folded metal plate.

13. A small-sized antenna for being mounted on a circuit substrate, comprising:

an antenna body; and

a resin-molded body that comprises a first resin-molded body and a second resin-molded body,

wherein the antenna body is sandwiched by the first and second resin-molded bodies,

the first resin-molded body engages to the second resin-molded body,

the first resin-molded body is adapted to be mounted on the circuit substrate,

the antenna body comprises an inverted-F antenna element that is formed in a cross-sectional L shape, the inverted-F antenna element comprising n engaging piece,

the first resin-molded body is formed substantially in a rectangular parallelepiped shape, the first resin-molded body comprising a top edge portion to contact the inverted-F antenna element and an engaging groove to engage to the engaging piece of the inverted-F antenna element, and

the second resin-molded body is formed substantially in a plate shape to cover the first resin-molded body while sandwiching the inverted-F antenna element therebetween, the second resin-molded body comprising an engaging piece to engage to an engaging hole of the first resin-molded body.

14. The small-sized antenna according to claim 13, wherein:

the first resin-molded body comprises on its back side a protruded boss to be fined into a positioning hole of the circuit substrate.

* * * * *